

WHAT IS CLAIMED IS:

1. A direct fuel injection engine comprising:
 - a combustion chamber;
 - a spark plug positioned in an upper surface of the combustion chamber;
 - 5 a fuel injection valve positioned in a substantially center portion of the upper surface of the combustion chamber, the fuel injection valve being configured and arranged to directly inject a fuel stream inside the combustion chamber;
 - a piston having a guide wall surface being configured and arranged to guide the fuel stream injected from the fuel injection valve; and
 - 10 a controller configured and arranged to control operations of the spark plug and the fuel injection valve,
 - the controller being further configured and arranged to ignite a first air-fuel mixture formed directly after the fuel stream is injected from the fuel injection valve and prior to a majority of the fuel stream being guide by the guide wall surface of the piston
 - 15 when the direct fuel injection engine is operating in a low-load stratified combustion region,
 - the controller being further configured and arranged to ignite a second air-fuel mixture formed after a majority of the fuel stream is guided to an upper portion of the combustion chamber by the guide wall surface of the piston when the direct fuel injection
 - 20 engine is operating in a high-load stratified combustion region.
2. The direct fuel injection engine as recited in claim 1, wherein
 - the controller is further configured and arranged to ignite the first air-fuel mixture before a tip of the fuel stream injected from the fuel injection valve reaches the piston
 - 25 when the direct fuel injection engine is operating in the low-load stratified combustion region.
3. The direct fuel injection engine as recited in claim 1, wherein
 - the piston includes a cavity defined by the guide wall surface, the cavity having a
 - 30 substantially circular horizontal cross sectional shape that is substantially concentric to the fuel stream injected from the fuel injection valve.

4. The direct fuel injection engine as recited in claim 3, wherein
the guide wall surface comprises a cavity bottom surface and a cavity peripheral
wall surface that extends from the cavity bottom surface, the cavity peripheral wall surface
5 being oriented at an angle formed between a piston axis and an approximate direction in
which the fuel stream is injected from the fuel injection valve.

5. The direct fuel injection engine as recited in claim 4, wherein
the controller is further configured and arranged to control the fuel injection valve
10 such that the fuel stream injected from the fuel injection valve first collides against the
cavity bottom surface and then is guided by the cavity peripheral wall surface toward the
upper portion of the combustion chamber to form the second air-fuel mixture when the
direct fuel injection engine is operating in the high-load stratified combustion region.

15 6. The direct fuel injection engine as recited in claim 4, wherein
the controller is further configured and arranged to control the fuel injection valve
such that the fuel stream injected from the fuel injection valve first hits the cavity
peripheral wall surface and then is guided by the cavity bottom surface toward the upper
portion of the combustion chamber to form the second air-fuel mixture when the direct
20 fuel injection engine is operating in the high-load stratified combustion region.

7. The direct fuel injection engine as recited in claim 1, wherein
the controller is further configured and arranged to change control parameters for
varying a penetration force of the fuel stream injected from the fuel injection valve, and
25 the controller is further configured and arranged to set the control parameters such
that the penetration force of the fuel stream when the direct fuel injection engine is
operating in the low-load stratified combustion region is smaller than the penetration force
of the fuel stream when the direct fuel injection engine is operating in the high-load
stratified combustion region.

8. The direct fuel injection engine as recited in claim 7, wherein
the controller is further configured and arranged to set a fuel pressure such that the
fuel pressure when the direct fuel injection engine is operating in the low-load stratified
combustion region is lower than the fuel pressure when the direct fuel injection engine is
5 operating in the high-load stratified combustion region.

9. The direct fuel injection engine as recited in claim 1, wherein
the controller is further configured and arranged to change control parameters for
controlling the fuel stream injected from the fuel injection valve, and

10 the controller is further configured and arranged to set the control parameters such
that the fuel stream reaches in a vicinity of the spark plug directly after the fuel stream is
injected from the fuel injection valve when the direct fuel injection engine is operating in
the low-load stratified combustion region and that the fuel stream reaches in the vicinity of
the spark plug after the fuel stream is guided by the guide wall surface when the direct fuel
15 injection engine is operating in the high-load stratified combustion region.

10. The direct fuel injection engine as recited in claim 9, wherein
the fuel injection valve is configured and arranged to inject the fuel stream such
that the fuel stream forms a circular cone shape, and

20 the controller is further configured and arranged to set the control parameters such
that a fuel injection angle of the fuel stream when the direct fuel injection engine is
operating in the low-load stratified combustion region is larger than the fuel injection
angle of the fuel stream when the direct fuel injection engine is operating in a high-load
stratified combustion region.

25 11. The direct fuel injection engine as recited in claim 10, wherein
the controller is further configured and arranged to set a fuel pressure such that the
fuel pressure when the direct fuel injection engine is operating in the low-load stratified
combustion region is higher than the fuel pressure when the direct fuel injection engine is
30 operating in the high-load stratified combustion region.

12. The direct fuel injection engine as recited in claim 10, wherein
the controller is further configured and arranged to set a pressure inside the
combustion chamber such that the pressure inside the combustion chamber at a time of
fuel injection when the direct fuel injection engine is operating in the low-load stratified
5 combustion region is lower than the pressure inside the combustion chamber at a time of
fuel injection when the direct fuel injection engine is operating in the high-load stratified
combustion region.

13. The direct fuel injection engine as recited in claim 10, wherein
10 the fuel injection valve is a dual-fluid fuel injection valve that injects fuel and air in
a predetermined ratio, and
the controller is further configured and arranged to set a fuel-air ratio such that the
ratio of the fuel to the air is higher when the direct fuel injection engine is operating in the
low-load stratified combustion region than when the direct fuel injection engine is
15 operating in the high-load stratified combustion region.

14. The direct fuel injection engine as recited in claim 10, further comprising
a combustion chamber guide wall surface having a substantially circular cone
shape located in the vicinity of a tip of the fuel injection valve.

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15. A direct fuel injection engine comprising:
means for forming a combustion chamber;
ignition means for igniting first and second air-fuel mixtures formed in the
combustion chamber;
25 fuel injection means for directly injecting a fuel stream inside the combustion
chamber;

fuel stream guiding means for guiding the fuel stream injected from the fuel
injection valve toward in the vicinity of the ignition means; and

control means for controlling the ignition means and the fuel injection means to
30 ignite the first air-fuel mixture formed directly after the fuel stream is injected from the
fuel injection means and prior to a majority of the fuel stream being guide by the guide
means when the direct fuel injection engine is operating in a low-load stratified

combustion region, and to ignite a second air-fuel mixture formed after a majority of the fuel stream is guided to an upper portion of the combustion chamber by the fuel stream guiding means when the direct fuel injection engine is operating in a high-load stratified combustion region.

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16. A method of operating a direct fuel injection engine comprising:

injecting a fuel stream directly into a combustion chamber;

selectively guiding the fuel stream toward a spark plug;

selectively igniting a first air-fuel mixture formed directly after the fuel stream is

10 injected into the combustion chamber and prior to a majority of the fuel stream being
guided back towards the spark plug when the direct fuel injection engine is operating in a
low-load stratified combustion region; and

selectively igniting a second air-fuel mixture formed after a majority of the fuel
stream is guided toward the spark plug when the direct fuel injection engine is operating in

15 a high-load stratified combustion region.